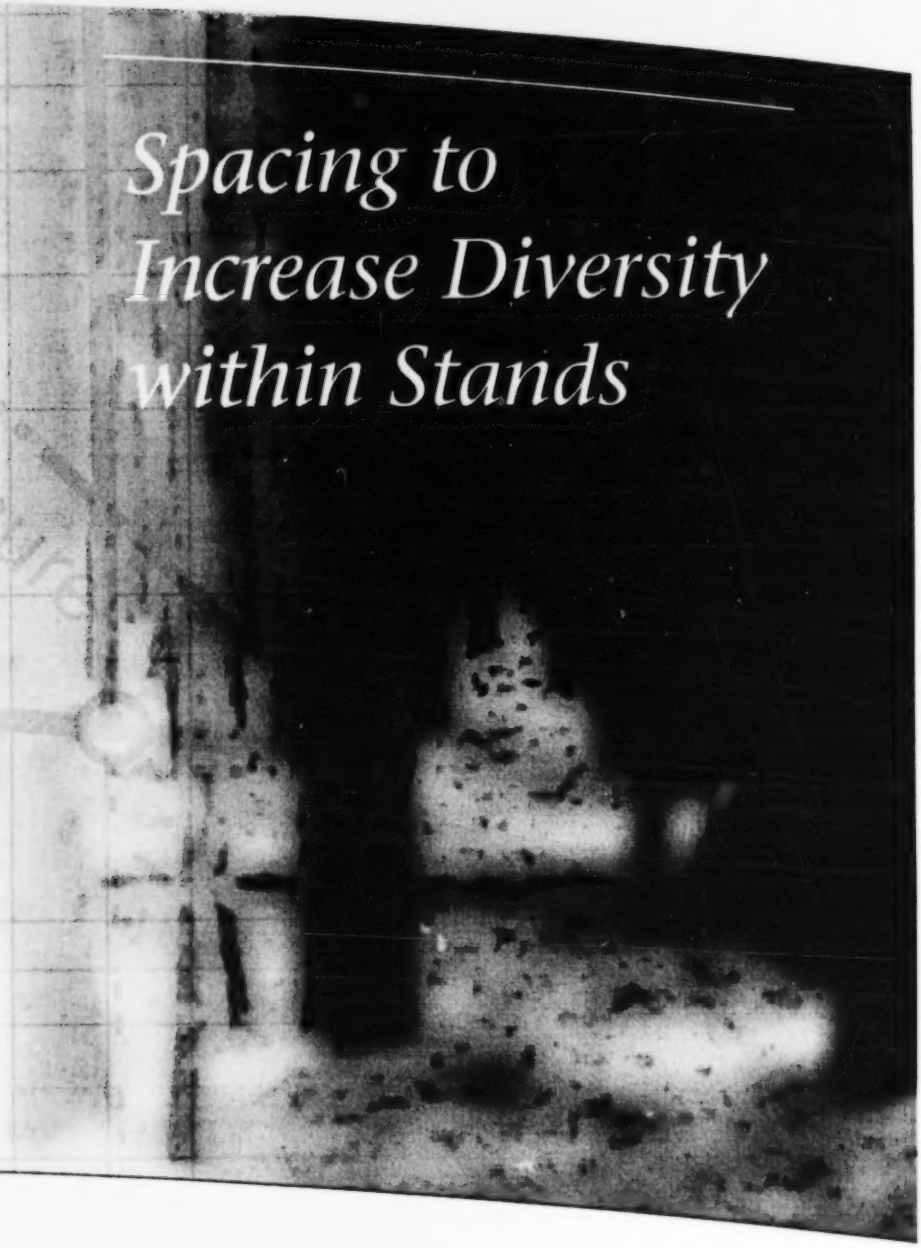
Stand Density Management Diagram

Supporting
Growth and Yield
Decision-making

Spacing to Increase Diversity within Stands



BRITISH COLUMBIA

FOREST PRACTICES

FOREST RENEWAL BC

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Introduction

Spacing, the cutting of small trees in young stands, may alter stand structural diversity. Traditional spacing prescriptions can be modified in many ways to preserve or promote diversity. Using Stand Density Management Diagrams (SDMDs), this pamphlet illustrates some growth and yield principles relevant to spacing prescriptions designed to enhance structural diversity within stands.

Structural Diversity

Stand structure refers to the distribution of trees and other plants in a stand by characteristics such as size, age, vertical and horizontal arrangement, or species composition. Some features of structural diversity that are associated with old natural forests—such as large trees and a multi-layered canopy—are significantly reduced or absent in young managed stands. Spacing can accelerate the restoration of some of these attributes, and enhance a stand's structural diversity. A diverse stand structure provides a variety of forest habitats for plants and animals and helps sustain important ecosystem processes.

Stand Density Management Diagrams

Stand Density Management Diagrams (SDMDs) depict the development of healthy, single-species, even-aged stands over time. An SDMD is a graph of the relationships among top height, mean diameter, stem density, and mean volume per tree as stands develop from various establishment densities. SDMDs are widely used in silviculture training programs to convey general stand development concepts.

Limitations

This pamphlet is not intended to promote any specific stand management regime. The post-spacing densities (and other values) used in the figures in this pamphlet illustrate general concepts; do not interpret them as recommendations for prescriptions.

To understand this pamphlet, you must know how to use an SDMD. To apply these concepts, you will need more detailed information on SDMDs, stand structural diversity, and spacing. See "*More Information*" on back cover.

Maintaining diversity within a landscape requires more than maintaining structural diversity within individual stands. It requires landscape-level management of the arrangement of stand types within a landscape.

Spacing prescriptions designed to enhance diversity may decrease timber yield and quality. The appropriate role for these regimes in forest management is currently under study and debate.

Glossary

Stand trajectory: A curved line on an SDMD that charts the changes in a stand's structure as it grows.

TASS: The Tree and Stand Simulator, a stand growth model.

Top height: The mean height of dominant trees.

Zone of imminent competition-mortality (ZICM): A zone on an SDMD indicating the probable occurrence of competition-based mortality in stands. The lower limit of the ZICM approximates the point at which self-thinning starts to dramatically accelerate.

This pamphlet is one in a series of information booklets on using SDMDs. Other topics include using SDMDs to manage for timber production, forest health, wildlife habitat, and visual quality.

Large Trees

A few large living trees contribute greatly to a stand's structural diversity. Yet large trees develop slowly in young, dense, unmanaged stands. Widely spacing a portion of a stand can accelerate diameter (but not height) growth and the development of some of the attributes of large trees.

Widely spacing a portion of a stand accelerates the growth of some trees, increasing stand structural diversity.

Figure 1
Spacing and large trees.
(T1) unspaced, reaches threshold diameter at 26 m height; (T2) spaced to approximately 500 trees per hectare (tph), reaches threshold diameter at 18 m height.

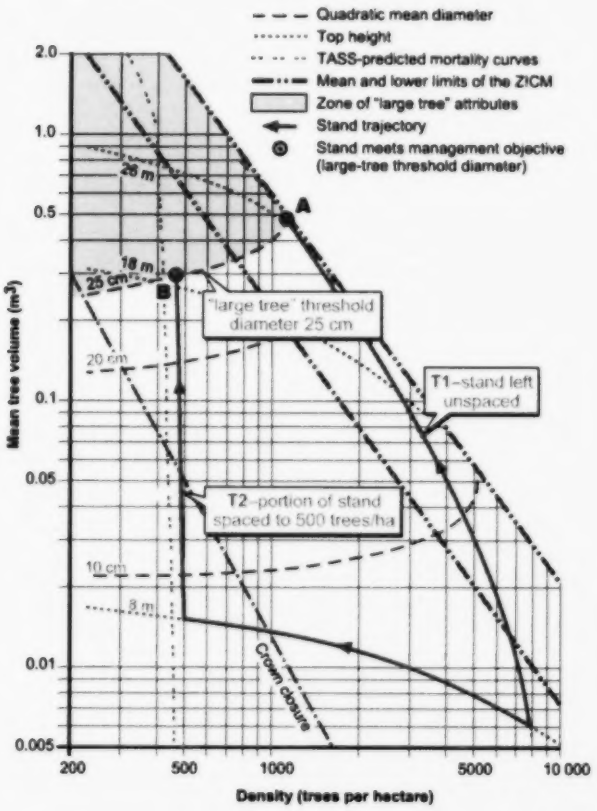


Figure 1 illustrates this concept for lodgepole pine assuming that a suitable index for "large trees" is a mean diameter of 25 cm.[1] A stand with a height of 8 m and a density of 8000 trees per hectare (tph), if left unspaced (T1), does not reach this large-tree threshold diameter until a height of 26 m (**A**). If a portion of the same stand is spaced to 500 tph (T2), the mean diameter of trees in this portion of the stand reaches the large-tree threshold diameter at a height of 18 m (**B**). In the widely spaced portion of the stand, large diameter trees are produced many years sooner.

Remember—the post-spacing density and large tree threshold values used in this example are intended to illustrate a general concept, not to recommend a prescription. The appropriate definition of "large trees" will vary by ecosystem.

[1] To indicate the presence of large trees, the mean diameter of the *largest trees* in the stand is a more useful statistic than the mean diameter of *all trees*. SDMDs show the mean diameter of all trees.

Large Crowns

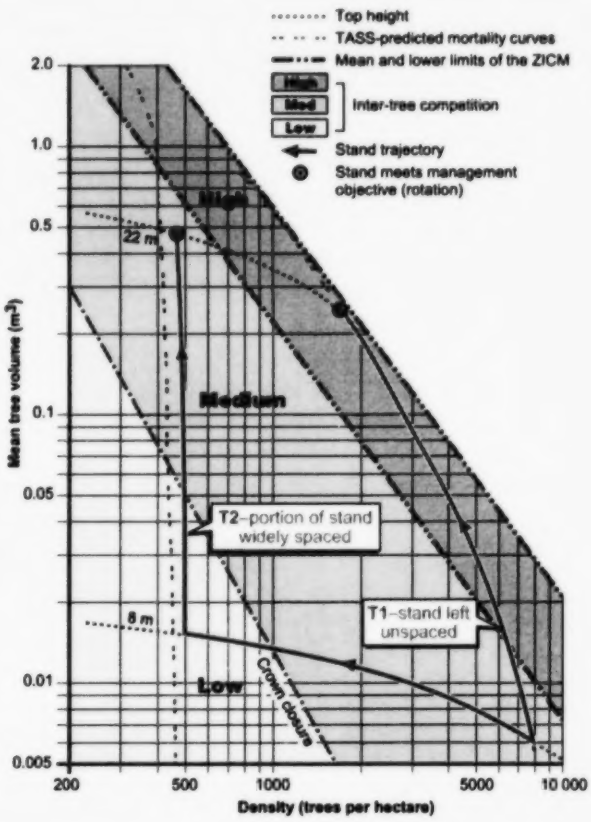
The presence of a few trees with large crowns enhances stand structural diversity. Large crowns contain large diameter branches that are suitable for nesting and perching, and for the development of arboreal plant and animal communities. Long crowns also contribute to canopy diversity within the stand.

4 *Crown development is a function of inter-tree competition.*

When trees grow under prolonged conditions of intense competition, tree crowns remain small. Three broad zones of inter-tree competition can be drawn on an SDMD: high competition in the zone of imminent competition-mortality (ZICM), low competition in the zone below the crown closure line, and medium competition in the zone between.

Figure 2 illustrates how widely spacing a portion of a young dense stand can greatly reduce inter-tree competition and allow some trees to develop large crowns. If left unspaced (T1), the stand will develop in the medium and high competition zones and the trees will develop small crowns with small diameter branches. However, if a portion of this stand is widely spaced (T2), it will develop with low and medium levels of competition, allowing some trees to develop longer, wider crowns with larger branches.

Figure 2
Spacing and large crowns.
(T1) unspaced, develops in medium and high inter-tree competition zones; (T2) widely spaced, develops in low and medium inter-tree competition zones.



Coarse Woody Debris and Snags

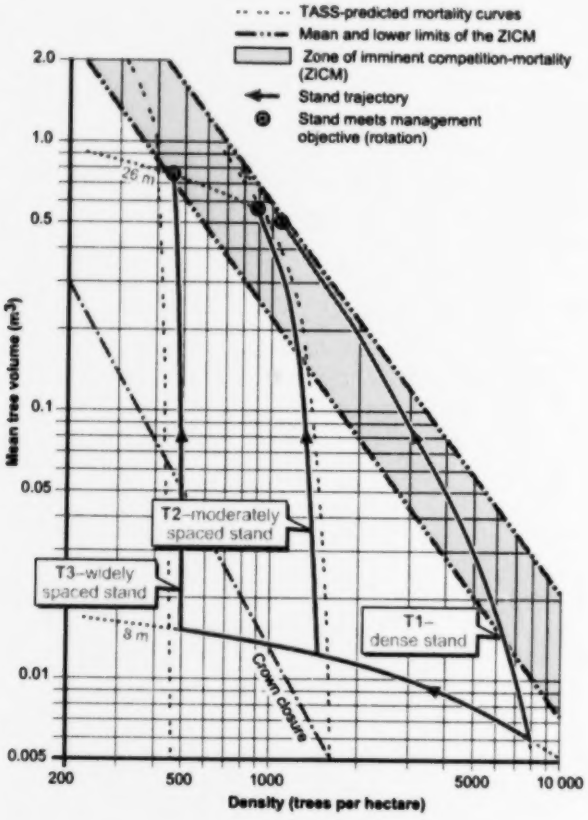
Standing dead trees (snags), dying trees, and large fallen logs are important contributors to a diverse stand structure. Where past logging practices have left few dead standing trees or minimal large coarse woody debris, these structural elements must be produced from mortality in the existing stand.

Stand density influences the future production of coarse woody debris and snags.

Tree mortality accelerates as stands enter the ZICM on the SDMD. Spacing delays the onset of mortality and reduces the cumulative volume of mortality.

Figure 3 illustrates that young dense unmanaged stands (T1) produce dead trees sooner than spaced stands (T2 and T3). If trees are very widely spaced (T3), there will be little competition mortality and the stand may produce almost no snags or coarse woody debris within a typical rotation.

Figure 3
Spacing and mortality, snags, and coarse woody debris.
(T1) unspaced – many trees die and mortality begins sooner; (T3) widely spaced – few trees die and mortality begins much later; (T2) moderately spaced – intermediate to T1 and T3.



Layered Canopy

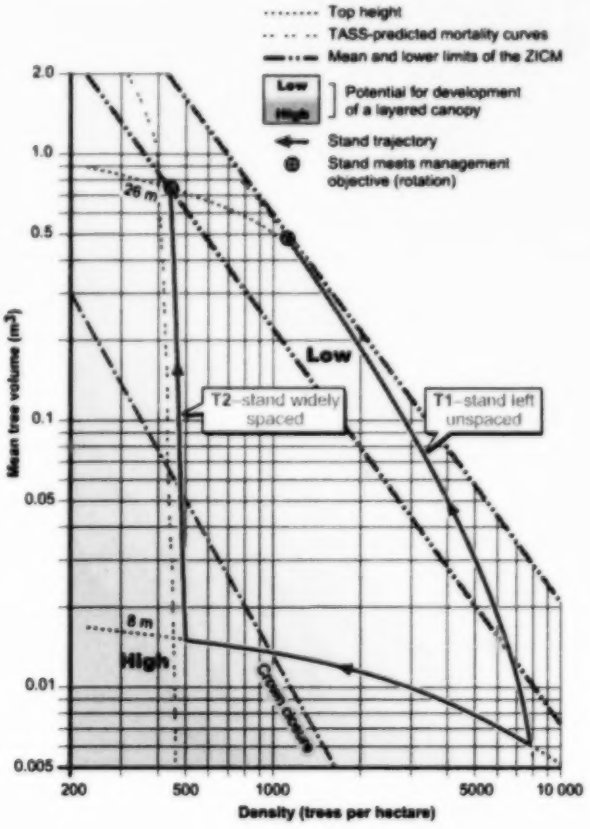
By making light available to understorey trees, spacing supports their survival and growth. Wide spacing promotes the development of a layered canopy, thus enhancing stand structural diversity.

Spacing can promote development of a layered canopy by making light available to understorey trees.

The potential for development of a layered canopy is roughly indicated by the location of the crown closure and ZICM lines on the SDMD.

Figure 4 illustrates this concept for a dense young stand. Without spacing (T1), the stand will remain in the zone of low potential for development of a layered canopy. Wide spacing (T2) moves the stand into the zone of high potential. In the spaced stand (T2), the potential for development of vertical canopy structure gradually declines as trees grow and crowns expand

Figure 4
Spacing and canopy layering.
(T1) unspaced, low potential to develop a layered canopy; (T2) widely spaced, high to medium potential to develop a layered canopy.



Spatial Diversity

In stands of uniform stocking, the distance between adjacent trees varies little, and spatial diversity is low. Variable density spacing can be used to create a variety of densities within a stand, and thereby increase stand diversity.

Spacing can be used to create varying densities within a stand.

Figure 5
Spacing and spatial diversity.
(T1) unspaced; (T2) moderately spaced; (T3) widely spaced.

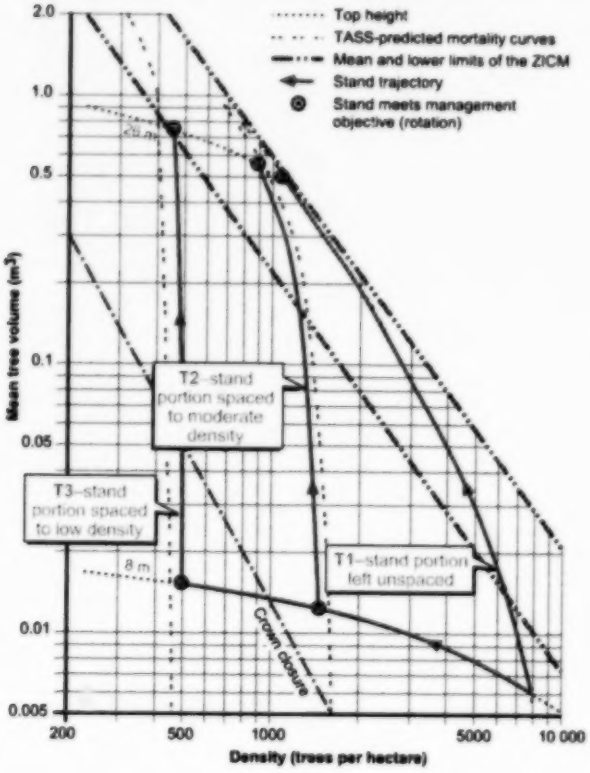


Figure 5 illustrates this concept for a dense, young stand. A portion of the stand is left unspaced (T1), a portion is spaced to moderate density (T2), and a portion is spaced to low density (T3).

Species Composition

Species diversity is an important component of stand structural diversity. Stand management activities such as spacing can have a significant impact on the species diversity of a stand. When prescribing and carrying out a spacing treatment, stand diversity can be enhanced by ensuring that the treatment does not remove a species from a stand. This concept cannot be illustrated on SDMDs as they represent the development of single-species stands.

More Information

Stand Density Management Diagrams

http://www.for.gov.bc.ca/hfp/pubs/standman/standen.htm

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SDMD Publications

B.C. Ministry of Forests. 1997. How to use a stand density management diagram: getting the stand and site data. For. Practices Br., Victoria, B.C.
http://www.for.gov.bc.ca/hfp/pubs/standman/SDMD_get.pdf

B.C. Ministry of Forests. 1997. How to use a stand density management diagram: yield predictions for a spacing prescription. For. Practices Br., Victoria, B.C.
http://www.for.gov.bc.ca/hfp/pubs/standman/SDMD_yld.pdf

Farnden, C. 1996. Stand density management diagrams for lodgepole pine, white spruce, and interior Douglas-fir. Can. For. Serv., Pac. For. Cent., Victoria, B.C. Info. Rep. BC-X-360.
http://leaf.pfc.cfs.nrcan.gc.ca/

Spacing and Structural Diversity

B.C. Ministry of Forests. 1998. Pre-commercial thinning operational guidelines. For. Practices Br., Victoria, B.C.
http://www.for.gov.bc.ca/hfp/pubs/pct/index.htm

B.C. Ministry of Forests. 1999. Guidelines for developing stand density management regimes. For. Practices Br., Victoria, B.C.
http://www.for.gov.bc.ca/hfp/pubs/stand_density_mgt/

B.C. Ministry of Forests and BC Environment. 1995. Biodiversity guidebook. For. Practices Code Guidebk., Victoria, B.C.
http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/biodiv/biotoc.htm

Carey, A.B. and R.O. Curtis. 1996. Conservation of biodiversity: a useful paradigm for forest ecosystem management. Wildl. Soc. Bull. 24(4):610–620.

Curtis, R.O., D.S. DeBell, C.A. Harrington, D.P. Lavender, J.B. St. Clair, J.C. Tappeiner, and J.D. Walstad. 1998. Silviculture for multiple objectives in the Douglas-fir region. U.S. Dep. Agric. For. Serv., Pac. N.W. Res. Sta., Portland, Oreg. Gen. Tech. Rep. PNW-435.

Hayes, J.P., S.S. Chan, W.H. Emmingham, J.C. Tappeiner, L.D. Kellog, and J.D. Bailey. 1997. Wildlife response to thinning young forests in the Pacific Northwest. J. For. 95(8):28–33.

Habitat Silviculture Protection Committee. 1993. Guidelines for maintaining biodiversity during juvenile spacing. B.C. Min. For. and BC Environ. Canada–British Columbia Partnership Agreement on Forest Resource Development: FRDA II, Victoria, B.C. Misc. Rep. MR-46. 25 p.

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